Zero Retries issue 0041 2022-04-08

Advanced Amateur Radio - Data Communications; Space; Microwave… the fun stuff! The Universal Purpose of Ham Radio is to have fun messing around with radios - Bob Witte K0NR. Ultimately, amateur radio must prove that it is useful for society - Dr. Karl Meinzer DJ4ZC. We are confronted by insurmountable opportunities! - Pogo. Nothing great has ever been accomplished without irrational exuberance - Tom Evslin. Irrational exuberance is pretty much the business model of Zero Retries Newsletter - Steve Stroh N8GNJ. What's life without whimsy? - Dr. Sheldon Cooper.

Zero Retries is a unique, quirky little highly independent, opinionated, self-published newsletter about technological innovation in Amateur Radio, for a self-selecting niche audience, that's free (as in beer) to subscribe.

About Zero Retries

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In this issue:

- **Request To Send**
- **The New Role of Amateur Radio in Emergency Communications (Abstract)**
- **Iridium Next Satellite System - Highly Capable Voice, Data, and Push To Talk "Radio"**
- **Starlink Satellite System - Broadband Internet Access**
- **FirstNET - Briefly**
- **Information Technology Disaster Resource Center (ITDRC) - Tech Task Force**
- **But… *That's Not Amateur Radio***
- **What Would Help Achieve Amateur Radio *Emergency* Data Network (AREDN)?**
- **Feedback Loop**
- **Join the *Fun* on Amateur Radio**
- **Closing The Channel**

Request To Send

Countdown to Hamvention 2022 - May 20-22, in Xenia, Ohio - 6 weeks…

In a private forum that I participate in, the collapse of Internet access and cellular in Ukraine was discussed. Amateur Radio was discussed in relation to providing replacement, or supplemental Internet communications in such a disaster, and this *good question was asked*:

> If Amateur Radio is useful but slow, what are the other options? And / or what could be done to make [Amateur Radio] an even better / more powerful option?

Long ago, my personal mental model of emergency communications was formed by a "Wise Amateur Radio Elder" explaining to me the "Edge of the Disaster" model of emergency communications. That is, absent a truly cataclysmic disaster that would affect a very wide region, the *most likely* disasters will be of limited scope in a defined area. Outside that defined area, normal communications are available. Thus the primary need for emergency communications inside a disaster area is to "bridge out" to the edge of the disaster to connect with normal communications.

While the Russia invasion of Ukraine *is* one of those rare cataclysmic disasters affecting a very wide region, that good question spawned this issue in distilling my thoughts on how Amateur Radio is going to have to evolve to stay relevant in providing emergency communications.

de Steve N8GNJ

The New Role of Amateur Radio in Emergency Communications (Abstract)

Amateur Radio's role in providing emergency communications is rapidly changing due to significantly enhanced capabilities of the (worldwide) Iridium satellite system, the (worldwide) Starlink satellite system, and the (USA) FirstNET cellular system.

These new communications capabilities can be rapidly deployed into disaster areas and set up by those with minimal technical skills. Thus Amateur Radio's traditional role of providing voice and slow-speed data communications via HF, VHF, and UHF frequencies will, increasingly, be unnecessary.

To be truly useful in providing emergency communications for present-day disasters, Information Technology (IT) skills will be *required*, such as how to diffuse Internet Access from a Starlink user terminal (beyond its minimal Wi-Fi range), set up Ethernet and Wi-Fi networks, build microwave networks, set up Voice over Internet Protocol (VOIP) telephone systems and other Internet-based systems, and troubleshoot networking issues. Such capabilities are already emerging, independent of Amateur Radio, such as the Information Technology Disaster Resource Center (ITDRC) organization.

Amateur Radio and Amateur Radio Operators *can* have a continuing role in emergency communications such as having practiced the discipline of managed voice nets (Incident Command System), established relationships with government agencies ("being badged"), and having personal tactical communications capability ("Go Kits, portable radios). An unappreciated capability of Amateur Radio Operators in an emergency is knowledge of basic electronics, such as providing power, setting up antennas (and what works and what doesn't),

even mundane skills as using a Volt Ohm Meter (VOM) and how to solder.

Iridium Next Satellite System - Highly Capable Voice, Data, and Push To Talk "Radio"

The first major change in communications that impacts Amateur Radio's traditional role in emergency communications is the upgrade of the Iridium satellite system completed in 2019. Iridium is the most capable[1] and most ubiquitous satellite phone service worldwide. Iridium is a constellation of seventy five satellites (plus in-orbit spares) in low earth orbit (LEO), which results in low-latency communications over the entire planet. Iridium is an ideal emergency communications system, especially for voice, because it has minimal dependence on ground infrastructure because communications between two Iridium devices are handled entirely in-network:

- Device ➡️ satellite
- Satellite ⬅️➡️ satellite ⬅️➡️ satellite (as needed)
- Satellite ➡️ device.

Communications between an Iridium device and a non-Iridium device are handled through Iridium earth stations, using the satellite to satellite to satellite relay until a Iridium earth station can be reached.

Prior to 2019, Iridium was "limping along" with their original satellite system launched in the early 2000s using technology from a decade earlier. The first generation Iridium satellites were not designed for data. In disasters, Iridium was often saturated, and phone calls could not be completed.

In 2019, Iridium completed the replacement of its *entire satellite constellation* to Iridium Next[2] satellites. I cannot find a direct comparison of the capacity of "old" Iridium to Iridium Next, but given the advancements of the past two decades, the capacity increase is "substantial".

Given the huge advantage of not requiring much ground infrastructure, and the significantly enhanced capabilities of Iridium, in my opinion, Iridium can now function as *primary communications in a disaster*. For example, Iridium now offers global push-to-talk service; effectively a repeater network that works literally anywhere.

While Iridium excels at voice communications, and the satellite upgrade greatly improved data rates and overall data capacity, Iridium is not a suitable replacement for broadband Internet connectivity. It's not really designed for that role.

Starlink Satellite System - Broadband Internet Access

The Starlink Broadband Internet Access system entered beta service 2020-10, and began commercial service 2021-11; it's still "early days" for Starlink.

The second major change in communications that impacts Amateur Radio's traditional role in emergency communications is the Starlink Satellite System which provides Broadband Internet Access.

Unlike existing "Broadband" satellite systems which are in Geosynchronous Earth Orbit (GEO), like Iridium, Starlink satellites are in Low Earth Orbit (LEO). Using LEO, Starlink has three key advantages over GEO satellites:

- Higher capacity - GEO satellites, despite using multiple spot beams, are easily saturated. A mental model of GEO satellite vs LEO satellite coverage is cellular telephony - when more capacity is needed, more cells (satellites) are added to provide additional frequency reuse and capacity.

- Low latency - transmissions to / from GEO satellites are 44,600 miles round trip which introduces latency that Internet applications (especially "live" video and voice") do not deal with well. LEO satellite orbits are as low as 155 miles, thus providing "normal" Internet latencies.

- GEO satellites provide marginal coverage of the polar regions. LEO satellites can provide polar orbits to provide excellent coverage of polar regions.

Currently, Starlink's system capacity is limited (waitlisted) as Starlink ground stations and additional satellites are added. Most current Starlink satellites operate in a "bent pipe" configuration - for communication to work, both a Starlink user terminal a Starlink ground station must be in the same "footprint" of an individual Starlink satellite. The newest, and all future Starlink satellites are equipped with inter-satellite links, though it will be some time before that capability is fully operational. Starlink eventually plans to scale to tens of thousands of satellites.

In contrast to Iridium, Starlink was designed to provide Broadband Internet Access. To maintain high data rates, microwave frequencies3 are used (shown in GHz):

- Satellite ➡️ user terminal - 10.7 - 12.7 and 37.5 - 42.5

- User terminal ➡️ satellite - 14.0 - 14.5, 47.2 - 50.2, and 50.4 - 51.4

Starlink satellites, ground stations, and user terminals all use a combination of mechanical tracking and phased array4 antennas to maintain focused beams between constantly moving satellites and ground stations and user terminals. Currently, Starlink ground terminals are "mostly stationary" and are designed for fixed use (they're rectangular - 12" x 19" and weigh 9 pounds). Starlink has stated that mobility will be a capability in the future, such as installation on vehicles and ships, and perhaps aircraft.

Starlink user terminals are user-installable - the terminal is shipped to the user, and the user assembles the unit, plugs in power, and enters a few parameters into a pocket computer app. The Starlink user terminal determines its location, passively monitors the Starlink satellites passing overhead, "locks on", and begins providing Broadband Internet Access.

What is "game changing" about Starlink that impacts Amateur Radio's traditional role in

emergency communications is the capability for user installation. This capability is being demonstrated, and evolved, in the Russia invasion of Ukraine - see Zero Retries 0036 - *Special Issue - Starlink In Ukraine - Remarkable!* Starlink user terminals are providing Broadband Internet Access in Ukraine without any infrastructure (other than power).

Thus, Starlink user terminals can now be drop-shipped, *or even parachuted*, into a disaster area, and *rapidly* installed by anyone with minimal technical capability to quickly begin providing *Broadband Internet Access*.

Thus, Broadband Internet Access can now be rapidly provided *inside* the disaster area. Broadband Internet Access means videoconferencing, video (camera) monitoring, voice (turn on Voice Over Wi-Fi on your mobile phone), and *all other services provided via Broadband Internet Access*.

Starlink's technologies and capabilities are rapidly evolving. A more capable Starlink user terminal for businesses was recently announced that will likely be more suitable for emergency communications and rapid deployment:

- Larger, higher-gain antenna for better reliability in marginal weather conditions.
- 150-500 Mbps throughput and latency of 20-40 ms
- Routable (static) IPv4 IP address
- Centrally managed and configured
- (Assumed) Ethernet connectivity as standard

Imagine such a unit appearing in a disaster area. It needs to be set up in an area clear of obstructions for maximum throughput. It needs to be powered, and secured. It needs to have Ethernet routers and or switches to be connected and the Internet connectivity be shared out via wireless connectivity (short range Wi-Fi won't be suitable).

FirstNET - Briefly

> The First Responder Network Authority is an independent authority within the U.S. Department of Commerce. Chartered in 2012, its mission is to ensure the building, deployment, and operation of the nationwide broadband network that equips first responders to save lives and protect U.S. communities.

FirstNET is essentially contracted, prioritized communications for public safety users on the AT&T's cellular network (*not*, as AT&T tries to portray, a dedicated, separate network). FirstNET has dedicated equipment on standby to deploy rapidly such as "Cells On Wheels" (COWs), and a variety of dedicated FirstNET radio equipment. The most significant aspect of FirstNET, versus previous, voluntary "best effort" of cellular carriers, is that FirstNET has specific, contracted service guarantees for public safety users. FirstNET is a US government entity and thus has dedicated staff, budget, and other resources to monitor, enforce, and if necessary, discipline AT&T if FirstNET service levels are not maintained. With FirstNET, it's at

least ~~less~~ more likely that, in a disaster, public safety use of cellular networks will remain usable.

With FirstNET, crates… probably *pallets*, of FirstNET portable devices are cached for rapid deployment. During a disaster, FirstNET portable devices (with varying levels of prioritization) are handed out to credentialed users… no Amateur Radio license, experience, etc. required.

Information Technology Disaster Resource Center (ITDRC) - Tech Task Force

Understanding the new capabilities of Iridium, Starlink, and FirstNET, which scenario do you think a disaster response agency would prefer?

- Write a message on a piece of paper which is passed along to an Amateur Radio Operator to transmit by (unencrypted) voice or packet radio or email (Winlink)? Or…
- Pick up a VOIP phone, or sit down at a laptop and send your own email, or go to a disaster response web page?

Lest you think that the above is alarmist speculation about the fading utility of Amateur Radio's role in Emergency Communications during disasters…

*This **is** already happening*. See ITDRC's Resources Page and reference the Tech Task Force of the Information Technology Disaster Resource Center (ITDRC):

> ITDRC's Disaster Tech Task Force is comprised of private sector partners that contribute skilled employee volunteers, products, services, and monetary support for disaster response operations in North America.
> Teams train and work in collaboration with NGOs and First Responders to engineer and deliver emergency communications and complex technical solutions that aid communities during and after catastrophic events.
>
> Typical Field Operations tasks include:
>
> - Providing "smart hands" to Public Safety and Emergency Management agencies.
> - Establishing temporary connectivity for partners providing relief.
> - Installing WiFi and charging stations in evacuation centers and shelters for survivors.
> - Lending IT equipment for response and recovery.

It's notable that ITDRC is aware of Amateur Radio; the volunteer application form asks if the applicant is an Amateur Radio Operator. But that's just one question about qualifications, among many others such as "server OS", "telephony", and "structured wiring".

ITDRC's Go-Bags and Gear recommendations are instructive. The only thing recognizable from a typical *Amateur Radio* "Go Bag" is a (generic) *Handheld PTT radio*. Suitable to ITDRC's focus is a suggestion to bring an *RJ-45 crimping tool and an RJ-45 cable tester*.

ITDRC lists an impressive number of tech companies as partners.

Also notable is that ITDRC is a unified national organization - no "local chapters" with volunteer local staff, etc. To volunteer with ITDRC, you interact with the national organization for deployments. (I don't know any more about their structure or volunteer management other than what is stated on the website.) It seems to me that in the era of instant, broadband communications, this model of management would seem more effective than decentralized, poorly-staffed, poorly-funded Amateur Radio emergency communications groups.

But… *That's Not Amateur Radio*

Amateur Radio's traditional role in disasters is to provide HF radio communications, as in show up with an HF radio, battery, some coax, and a dipole antenna. Throw the antenna up into some trees, hook up the radio to the battery and antenna, and start communicating outside the disaster area. That particular response is still viable, especially in the era of data modes and smaller HF radios, but the capabilities of HF are severely by data speeds and voice communications possible over HF.

That said, HF certainly still has its role, and is still applicable for when there is no infrastructure whatsoever. But increasingly, the usefulness of HF is limited, primarily because what is most often needed in a disaster is high speed data communications such as Internet, and not a "thin straw" of data communications that is possible with HF.

But in the 2020s, with Iridium, Starlink, and FirstNET, Amateur Radio's traditional role of providing voice and low-speed data communications is less relevant. As discussed in the Abstract:

> Amateur Radio and Amateur Radio Operators *can* have a continuing role in emergency communications…

I posit that Amateur Radio as a whole needs to re-interpret "emergency communications" to be more relevant, more like the Tech Task Force of ITDRC.

Some examples:

- Amateur Radio Emergency Data Network (AREDN) Microwave IP Mesh Networks are increasingly capable and easy to set up. They are a complement to a Starlink user terminal for expanding Internet access beyond the range of the Starlink user terminal's built-in Wi-Fi. Suitable units for use with AREDN aren't expensive, and it's within the capabilities of Amateur Radio Emergency Communications organizations to create a cache of AREDN units and appropriate battery power supplies so that an AREDN network can be rapidly deployed - as simple as hanging a unit in a tree or a pole (lightly waterproofed, such as a zippered plastic bag).

- In conjunction with AREDN units, have cached IP cameras and VOIP telephones for easy, fast communications.

- Similarly, set up several APRS Digipeaters with Igate capability so that APRS positions can be gatewayed into the Internet for remote display of positions.

- Amateur Radio Operators are now expert at joining repeaters into repeater networks via Internet; perhaps have a repeater that is cached and ready to deploy and easily connected to whatever Internet is available (such as AREDN).

- Wi-Fi will be the primary method of accessing Internet, and Amateur Radio Operators need to be experienced at setting up Wi-Fi systems, especially managing frequencies and access.

In short, the role of Amateur Radio in a disaster shouldn't be to attempt to use Amateur Radio capabilities to *replace* damaged communications infrastructure. Instead, Amateur Radio needs to adapt to the new realities by helping with helping restore communications capability of the 21st century rather than the mid-20th century.

What Would Help Achieve Amateur Radio *Emergency* Data Network (AREDN)?

I'm a fan of what the AREDN developers have accomplished in firmware with off-the-shelf Wi-Fi and Wireless ISP hardware. I'm also a big fan of AREDN (and other independent Amateur Radio microwave) networks that are pre-deployed. But I think those two scenarios could be significantly enhanced with better hardware that helps the developers and improves the possibilities of rapid deployment post-disaster.

Perhaps someone could come up with "made for Amateur Radio" devices for AREDN instead of merely using existing Part 15 (license-exempt) Wi-Fi and WISP hardware . There *are* development funds available. Here are some hardware ideas for more capable AREDN hardware:

- Higher power - Amateur Radio is a licensed radio service and thus legal to run higher power than Part 15 users. Build a unit that provides higher power than Part 15 devices, sold only to Amateur Radio Operators.

- More RAM - AREDN is trying to do a lot more than just route packets, such as mesh networking. AREDN software would benefit a lot from more RAM (more features = more user friendly = even easier deployments).

- Create a version of AREDN hardware for 1240 - 1300 MHz. AREDN works great in 10 MHz channels (6 in 1240 - 1300), and even 5 MHz channels (12 in 1240 - 1300).

- AREDN units should, ideally, be powered from standard 12 volts DC so they can easily be powered with salvaged car batteries, etc. that Amateur Radio is used to working with.

Updata

In Zero Retries 0038 I discussed the Halo TD-XPAH - New 902-928 MHz 802.11ah Radio:

> At the moment, I can't determine if it would be usable "out of the box" or to make it usable you would have to be a comfortable with software development. For example, there's no mention of how interact with the device (for example, no mention of an easy-to-get-started web GUI, for us non-developer mortals). I guess I should take the hint that the full title of the unit on Crowd Supply is Halo TD-XPAH *Development Board*.

While the developers didn't respond to my email, they have posted several updates on their project, including this response to my question:

> *Question*: Do I need to be a software or hardware developer to use this product?
>
> This product is primarily designed for developers who would like to create 802.11ah products. That said, we will provide open source code & pre-compiled binaries to support the three add-on boards. We will also support the Arducam 5MP Mini Plus OV5642 SPI camera, which is available from many common sources.

I'm reassured that they have also developed a GUI that looks reasonable for my purposes. As I write this, they've achieved 193% of their funding goal.

Feedback Loop

Nathan Rodland KI5NZE re: Zero Retries 0039 - *Fantastic. I wish I'd had this Projects & Systems list when I first got started. There are so many new and exciting things happening in the hobby, but it can be incredibly difficult to find - especially for new hams.*

Nathan - Thanks for the kind words. I agree, and glad it pointed you to some new and interesting things to learn about.

Join the *Fun* on Amateur Radio

If you're not yet licensed as an Amateur Radio Operator, and would like to join the fun by *literally having a license to experiment with radio technology*, check out **Join the Fun on Amateur Radio** for some pointers.

Closing the Channel

In its mission to highlight technological innovation in Amateur Radio, grow Amateur Radio, and make it more relevant to society in the 2020s and beyond, Zero Retries is published via email and web, and is available to anyone at no cost. Zero Retries is proud *not to participate* in

the Amateur Radio Publishing Industrial Complex!

My ongoing ***Thanks*** to:

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- Southgate Amateur Radio News consistently surfaces "Zero Retries Interesting" stories.
- The Substack email publishing platform makes Zero Retries possible. I recommend it for publishing newsletters.

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All previous issues of Zero Retries are available without restriction (no paywalls). For some background, Zero Retries 0000 was the **Introduction Issue**. Zero Retries 0026 and Zero Retries 0027 were a **2021 Year End Review** of Zero Retries. Every "decade" issue of Zero Retries is an overview of "Zero Retries Interesting" projects, etc.

More bits from Steve Stroh N8GNJ:

- SuperPacket blog - *Discussing new generations of Amateur Radio Data Communications - beyond Packet Radio (a precursor to Zero Retries)*

- N8GNJ blog - *Amateur Radio Station N8GNJ and the mad science experiments at N8GNJ Labs - Bellingham, Washington, USA*

Thanks for reading!
Steve Stroh N8GNJ / WRPS598 (He / Him / His)
These bits were handcrafted in beautiful Bellingham, Washington, USA
2022-04-08

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1

Others are comparatively limited in scope and capability. Globalstar uses bent pipe model, thus a user terminal and earth station must be in the same satellite footprint for communications to occur. Inmarsat uses GEO satellites and portable user devices are marginal at higher latitudes. Thuraya is geographically limited to the Eastern Hemisphere.

2

"Iridium Next" was Iridium's project name for the far more capable second generation Iridium satellites.

3

My thanks to the ELONX Starlink Compendium for this comprehensible list of frequencies.

4

Essentially, a directional radio signal is "steered" electronically with no physical motion.